REPORT

Geotechnical Desktop Study

Proposed Starbucks Building
1910 Bank Street
Ottawa, Ontario

Submitted to:

RioCan Management Inc.
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Submitted by:

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Distribution List

1 e-copy - RioCan Management Inc.

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Table of Contents

1.0 INTRODUCTION

This report presents the results of a desktop geotechnical study carried out by Golder Associates Ltd. (Golder), in support of the design of a new Starbucks store to be located on the property at 1910 Bank Street in Ottawa, Ontario.

This report presents factual historical borehole record data at the site with a summary of the locations of boreholes and their information source. As part of the current assignment, previously collected subsurface information pertinent to the site was reviewed and compiled. This existing subsurface information was contained in the following:

- Report prepared by Golder for Mother’s Restaurants Incorporated titled “*Soil Investigation, Proposed Mother’s Restaurant, Bank Street, Ottawa, Ontario*”, dated August 1979.

Based on an interpretation of the factual information available for this site, a general description of the soil and groundwater conditions across the site is presented. These interpreted subsurface conditions and available project details were used to perform the analyses and provide preliminary geotechnical recommendations for the design of the foundation for the proposed structure, including any construction considerations which could influence design decisions. No further field investigation was completed for this geotechnical desktop study.

The reader is referred to “Important Information and Limitations of this Report,” which are found at the end of this report but are an integral part of this document.

2.0 SITE AND PROJECT DESCRIPTION

The property at 1910 Bank Street is currently occupied by a single storey Swiss Chalet restaurant at the northeast corner, and the remainder of the site is occupied mostly by parking areas with a grassed and landscaped area immediately south of the existing restaurant. The main access road to the site is located along the south property limit.

From the preliminary plans provided by RioCan, it is understood that a new Starbucks store will be constructed to the south of the existing Swiss Chalet building, and immediately north of the main access road. A drive through loop will be located between the Swiss Chalet building and the new Starbucks. The new Starbucks and drive through loop will be located in the area that is currently grass covered.

From these preliminary plans, the new structure will be rectangular in shape with a length of about 31 metres and a width of about 11 metres. It is understood that the new structure will be one storey in height with a slab on grade.

From published geology mapping from the Ontario Geological Survey (OGS) and the previous geotechnical investigations, the site is indicated to be underlain by shallow overburden (i.e., generally less than 1 to 2 metres) over shale bedrock of the Carlsbad formation.

3.0 PROCEDURE

Pertinent subsurface geotechnical data from a previous 1979 Golder project carried out at the same site, was pulled out of the archive records and reviewed. The subsurface information from the previous investigation was used to carry out the current desktop geotechnical study.

4.0 SUMMARY OF SUBSURFACE CONDITIONS

The subsurface conditions encountered in the 4 previous boreholes from the 1979 Golder study were reviewed for the purpose of providing a general summary in this report, and are shown on the Record of Borehole Sheets in Appendix A. It is important to note that subsequent development of the site after the 1979 Golder study could have changed the soil conditions within at least the upper few metres from those observed and documented in the previous boreholes.

In general, the subsurface conditions at this site (as observed in 1979) consist of fill over till overlying weathered shale bedrock.

4.1 Fill

Fill was encountered from ground surface at all of the borehole locations. At boreholes 1 and 2, the fill consists of silty sand with some gravel. Glass and boulders were also noted in the fill at these locations. At boreholes 3 and 4, the fill consists of crushed stone. The fill extends to depths of between about 0.1 to 1.0 metres below the ground surface at the time the boreholes were drilled.

The result of grain size distribution testing carried out on one sample of the fill material is provided in Appendix A.

A 0.3 meter thick layer of buried topsoil was encountered at a depth of 0.8 meters beneath the fill at borehole 2.

4.2 Sandy Silt

A thin layer of brown sandy silt was encountered beneath the fill in boreholes 3 and 4. The layer has a thickness of between 0.2 and 0.3 metres and extends to a depth of 0.4 metres below the ground surface at the time the boreholes were drilled.

4.3 Till

A deposit of native glacial till was encountered below the fill, topsoil, and/or sandy silt in all of the boreholes. The glacial till generally consists of a heterogeneous mixture of gravel, cobbles, and boulders in a matrix of sandy silt with a trace of clay. The glacial till was encountered at depths ranging from between about 0.4 and 1.0 metres below the existing ground surface and was proven to extend to depths ranging from between about 0.7 and 1.5 metres below the ground surface at the time the boreholes were drilled.

Standard Penetration Test (SPT) “N” values measured in the till ranged from 10 to 29 blows per 0.3 metres of penetration indicating a loose to compact state of packing.

The result of grain size distribution testing carried out on one sample of the till is provided in Appendix A.

4.4 Refusal and Bedrock

Brown shale bedrock underlies the glacial till at all the borehole locations. The upper portion of this shale bedrock has been weathered and was augerable before encountering refusal on what is considered to be more competent shale bedrock. Some penetration of the weathered bedrock by means of a split spoon sampler was also possible.

The following table summarizes the weathered bedrock surface and refusal depths and elevations as encountered in the boreholes as part of the current investigation.

Borehole No.	Ground Surface Elevation (m)	Elevation of Weathered Bedrock Surface (m)	Depth to Weathered Bedrock Surface (m)	Depth to Auger Refusal within Bedrock (m)
1	88.8	87.3	1.5	2.6
2	88.5	87.1	1.4	2.5
3	89.2	87.9	1.2	2.1
4	88.4	87.7	0.7	1.5

4.5 Groundwater

No groundwater was observed during the current investigation.

The groundwater levels at the site are expected to fluctuate seasonally in response to changes in precipitation and snow melt, and is expected to be higher during the spring and periods of precipitation.

5.0 DISCUSSION

5.1 General

This section of the report provides engineering guidelines on the geotechnical design aspects of this project based on our interpretation of the existing borehole information and project requirements, and is subject to the limitations in the “Important Information and Limitations of This Report” attachment which follows the text of this report but forms an integral part of this document.

The foundation engineering guidelines presented in this section have been developed in a manner consistent with the procedures outlined in Part 4 of the 2012 Ontario Building Code (OBC) for Limit States Design.

Based on our review of the existing subsurface information from previous studies, it was determined that sufficient information existed for this site to meet the City of Ottawa requirements for geotechnical investigations, and no new fieldwork was required.

5.2 Excavations and Site Servicing

Based on the site conditions, it is anticipated that excavations for the construction of the foundations will be through the existing pavement structure or topsoil, where present, the existing fill, silt, and glacial till, and into the underlying bedrock.

No groundwater inflow was observed at the time of investigation. However, ground groundwater inflow into the excavation can be expected. It should however be possible to handle ground and surface water inflows by pumping from well filtered sumps established in the floor of the excavations.

No unusual problems are anticipated in excavating the overburden using conventional hydraulic excavating equipment. The Occupational Health and Safety Act (OHSA) of Ontario indicates that side slopes in the overburden above the water table could be sloped no steeper than 1 horizontal to 1 vertical (i.e., Type 3 soil) down to the bedrock surface. Boulders larger than 0.3 metres in diameter should be removed from the excavation side slopes for worker safety.

Excavation into bedrock will require mechanical break-up using a hoe ram or rock splitters. For further ease of excavation, the use of line drilling and/or pre-drilling in addition to the use of mechanical break-up equipment could also be considered. Due to the proximity of the excavation to the existing building, and the relatively small footprint of the new structure, drill and blast techniques are not considered appropriate for this project.
Near vertical trench walls in the bedrock should stand unsupported for the construction period provided that any loose pieces of the bedrock are scaled off the faces for worker safety. Where the excavation extends deeper than 1.8 metres into the bedrock, the near vertical walls should be reviewed by a geotechnical engineer for any sign of unstable pillars or slabs that should be removed or stabilized. Stabilization options could consists of rock anchors, mesh, shotcrete, sloping the side slopes or a combination thereof. The appropriate stabilization methodology, if required, will depend on the actual site conditions during construction, and further guidance can be provided at that time.

Where vertical bedrock walls greater than 1 metre in height will be located within the zone of influence of the existing foundations (i.e., down and out from the existing footing at a slope of 1 horizontal to 1 vertical), a geotechnical engineer should review the condition of the rock mass prior to proceeding any deeper with the bedrock excavation.

Where new buried services are to be installed, all uncontrolled fills, topsoil and other deleterious materials should be removed from under the new services. At least 150 millimetres of OPSS Granular A should be used as pipe bedding for sewer and water pipes. Where unavoidable disturbance to the subgrade surface does occur, it may be necessary to place a sub-bedding layer consisting of compacted OPSS Granular B Type II beneath the Granular A or to thicken the Granular A bedding. The bedding material should in all cases extend to the spring line of the pipe and should be compacted to at least 95 percent of the standard Proctor maximum dry density.

Cover material, from spring line of the pipe to at least 300 millimetres above the top of pipe, should consist of OPSS Granular A or Granular B Type I with a maximum particle size of 25 millimetres. The cover material should be compacted to at least 95 percent of the standard Proctor maximum dry density.

5.3 Subgrade Preparation

In preparation for construction of the new structure, the topsoil, fill, and any loose, wet, and disturbed material (including materials disturbed during excavation) should be removed from within the proposed structure footprint. Any softened or poorly performing areas of the subgrade soils must be subexcavated and replaced with engineered fill comprised of OPSS Granular B Type II or lean concrete. Engineered fill should be placed in lifts no greater than 300 millimetres in thickness and must be compacted to at least 95 percent of its Standard Proctor maximum dry density using suitable vibratory compaction equipment.

Engineered fill, if used, will need to be placed within the full zone of influence of the structure, which is considered to extend down and away from the outside edge of the footings at a slope of one horizontal to one vertical (1H:1V). Full-time inspection and in situ density testing should be carried out by a qualified geotechnical engineering firm during placement of engineered fill beneath proposed structures and/or other settlement sensitive areas.

5.3.1 Protection of Expansive Shale Subgrade

Excavation for the foundations may result in exposure of the shale bedrock to air. The shale bedrock at this site has the potential to swell following exposure to oxygen. This process involves a series of chemical reactions, some of which are purely chemical and others of which are at least catalyzed by micro-organisms. The general mechanism is considered to be that pyrite (FeS_2), which is present at low concentrations in the shale, weathers in the combined presence of oxygen and water to form sulphuric acid. That sulphuric acid then reacts with calcite, which is also present within the shale either as an integral part of the rock or as infilling, to form gypsum. The gypsum crystals tend to form within existing fractures and are volumetrically larger than the materials that formed them, thus resulting in heaving. Other mineral by-products of these reactions, such as the mineral jarosite, form a yellowish powder that is a characteristic indicator of this process.

For the above reactions to occur, there must be both water and oxygen available. It is considered that this new excavation may introduce oxygen to the shale if left unprotected.

It is also possible for the products of the above reactions to attack the concrete (i.e., sulphate attack).

To prevent expansion of the shale and/or reaction with the concrete, the shale must be protected from exposure to oxygen both in the long term as well as temporarily during construction. During excavation of the foundations and storage structure, the exposed shale subgrade should be covered as soon as practical with a full strength (25 MPa) concrete mud slab layer. Construction planning should ensure the shale is not left exposed and uncovered overnight. It is unlikely that the form work, installation of steel reinforcements, and the concrete pour for the footings can all occur on the same day. Therefore, provisions should be made to include a concrete mud slab to cover the shale rock on the same day that it is exposed.

That concrete mud slab should be made with sulphate resistant cement (HS or HSb). Where shale is exposed on the sides of the excavation, the mud slab should be placed such that the concrete covers the shale to the top-of-rock level. This could be accomplished by sloping the bedrock on the sides of the excavation to allow the concrete to stay in place, or by using shotcrete on the vertical bedrock surfaces.

5.4 Foundations

The proposed structure can be supported on conventional spread footings founded on or within the bedrock. The existing fill is not suitable to support foundation loads. All footings should be placed on the same medium (i.e., bedrock). Although it is not anticipated at this site, the bedrock surface could be lower in some localized areas. Where the bedrock is found to be at a lower elevation than the new footings, the use of lean concrete (i.e., with a minimum unconfined compressive strength of at least 20 megapascals) could be considered between the bedrock surface and the new foundations, or the new foundations could be lowered onto the bedrock surface. The surface of the bedrock should be adequately cleaned of any loose soil or debris prior to the placement of the foundations.

Spread footings placed on the weathered bedrock surface can be designed using a net Serviceability Limit States (SLS) bearing resistance of 250 kilopascals and a factored Ultimate Limit States (ULS) bearing resistance of 500 kilopascals. The SLS values provided above correspond to total and differential settlement values of 25 and 12 millimetres, respectively.

The factored bearing resistance at ULS footings placed on the unweathered bedrock surface may be taken as 1,000 kilopascals. The shale bedrock is considered an unyielding material and, as such, Serviceability Limit States (SLS) does not apply (i.e., less than 25 millimetres of settlement at ULS bearing resistance).

The ULS bearing resistance values given above include a resistance factor of 0.5 in accordance with OBC 2012.

There are no grade raise restrictions for the above bearing resistances.

5.5 Seismic Design

The 2012 Ontario Building Code (OBC 2012) contains seismic analysis and design methodology. The seismic Site Class value, as defined in Section 4.1.8.4 of the OBC 2012, depends on the average shear wave velocity of the upper 30 metres of soil and/or rock below founding level. The OBC permits the Site Class to be specified based solely on the stratigraphy and in situ testing data (i.e., shear strengths and standard penetration test results), rather than from direct measurements of the shear wave velocity.

Based on the in situ testing data, this site can be assigned a Site Class of C for seismic design purposes according to the 2012 OBC. A higher site class (i.e. a Site Class A or B) would likely be applicable for footings on or within 3 metres of the shale bedrock; however, this would need to be confirmed with site specific shear wave velocity testing.

5.6 Foundation Wall Backfill

The soils at this site are frost susceptible and should not be used as backfill against exterior or unheated foundation elements. To avoid problems with frost adhesion and heaving, these foundation elements should be backfilled with non-frost susceptible soils that meet the requirements of OPSS Granular B Type I. The backfill should be compacted to 95 percent of the material’s standard Proctor maximum dry density using suitable compaction equipment. To reduce compaction induced stresses only light compaction rollers or plate tampers should be used within 1 metre of the wall.

In areas where pavement or other hard surfacing will abut the proposed structure, differential frost heaving could occur between the granular fill and the adjacent areas. To reduce this differential heaving, the backfill adjacent to the wall should be placed to form a frost taper. The frost taper should be brought up to pavement subgrade level from 1.5 metres below finished exterior grade or from the bedrock surface, whichever is higher, at a slope of 3 horizontal to 1 vertical, or flatter, away from the wall. The granular fill should be placed in maximum 300 millimetre thick lifts and should be compacted to at least 95 percent of the material’s standard Proctor maximum dry density using suitable vibratory compaction equipment. Perimeter drains may also be used to drain the granular backfill in areas with hard surfacing in order to improve the pavement life. If used, this drain line should be provided with a granular surround and should lead by gravity drainage to a positive outlet (i.e., storm sewer or to a sump pit from which water is pumped).

5.7 Frost Protection

The soils and shale bedrock at this site are considered to be frost susceptible. Therefore, all exterior foundation elements of a heated building should be provided with a minimum of 1.5 metres of earth cover for frost protection purposes. Isolated, unheated exterior footings adjacent to surfaces which are cleared of snow cover during winter months should be provided with a minimum of 1.8 metres of earth cover.

If 1.5 metres of earth cover cannot be provided, insulation of the bearing surface with high density insulation could be considered as an alternative to earth cover for frost protection. Details for insulation of footings can be provided if required.

5.8 Pavement Design

In preparation for pavement construction, all topsoil, unsuitable fill, disturbed, or otherwise deleterious materials (i.e., those materials containing organic material) should be removed from the pavement areas. Some of the existing fill could remain provided that it is free of organic matter, and that the subgrade be subjected to a proof roll with a loaded tandem truck to reveal weak or soft areas prior to the construction of the new pavement structure. Soft or weak areas should be removed and repaired with acceptable earth borrow or OPSS Select Subgrade Material (SSM).

Pavement areas requiring grade raising to proposed subgrade level should be brought to grade using acceptable (compactable and inorganic) earth borrow or OPSS SSM. These materials should be placed in maximum 300 millimetre thick lifts and should be compacted to at least 95 percent of the materials standard Proctor maximum dry density using suitable compaction equipment.

The surface of the pavement subgrade should be crowned or sloped to promote drainage of the pavement granular structure towards perimeter swales or subdrains placed at the subgrade level

The following light duty pavement design is recommended for this project:

Material		Light Duty Pavement Thickness of Pavement Elements (mm)
Bituminous Concrete OPSS 1150	Superpave 12.5 mm	60
	Superpave 19.0 mm	-
Granular Material OPSS 1010	Granular A Base	150
	Granular B, Type II Subbase	300
	Prepared and Approved Subgrade	

The granular base and subbase materials should be uniformly compacted as per OPSS 310, Method A. The asphaltic concrete should be compacted in accordance with the procedures outlined in OPSS 310.

The asphaltic cement should consist of PG 58-34 and the design of the mixes should be based on a Traffic Category B.

The above pavement designs are based on the assumption that the pavement subgrade has been acceptably prepared (i.e., grade raise fill has been adequately compacted to the required density and the subgrade surface not disturbed by construction operations or precipitation). Depending on the actual conditions of the pavement subgrade at the time of construction, it could be necessary to increase the thickness of the subbase and/or to place a woven geotextile beneath the granular materials.

Where the new pavements will connect to existing pavements, the new pavement structures should be continued at least to the limits of construction, with any longitudinal transitions and/or tapers occurring thereafter. At these locations, the longitudinal transitions should be constructed by cutting the existing pavement structure vertically to the bottom of the existing subbase. The new granular layers should then be tapered up or down, as required, at a slope of 5 horizontal to 1 vertical to match the existing pavement structure. The asphaltic concrete does not need to be tapered between the new construction and the existing pavement. However, the asphaltic concrete of the existing pavement should be milled back an additional 300 millimetres to a depth of about 60 millimetres in areas where its thickness is greater than 100 millimetres, or matching the proposed surface course of the new asphaltic concrete. A tack coat should be provided and the new surface course asphaltic concrete placed over the milled surface to form the new pavement joint. Where the existing pavement is less than 100 millimetres, then a butt joint on a vertical saw cut surface is acceptable. A tack coat should be placed on the vertical saw cut surface. The tack coat should be in accordance with the City SP F-3107.

5.9 Corrosion and Cement Type

No testing was completed during the previous investigation related to potential sulphate attack on buried concrete elements and corrosion of buried ferrous elements; however, the shale bedrock at this site is known to be both acid generation and contains sulfides that can attack both concrete and steel.

It is therefore proposed that concrete with Type HS or HSb hydraulic cement be acceptable for substructures below the original bedrock surface. The subsurface conditions are also considered to be very corrosive to buried steel, and adequate corrosion protection should be provided to any permanent buried steel elements.

6.0 CLOSURE

As discussed previously, a geotechnical engineer should be present at the beginning of the excavation work to confirm that soil conditions are consistent with those identified during this assessment. An additional visit is required if the excavation remains open for more than a week.

We hope this report meets your current needs. Please contact us for any question about this report or concerning additional services for this project.

Golder Associates Ltd.

LICENSED PROFESSIONAL ENGINEER
SG
S. L GHADBANE
100184126
Sept 12/18
PROVINCE OF ONTARIO

Sarah Ghadbane, P.Eng.
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https://golderassociates.sharepoint.com/sites/30868g/deliverables/geotechnical desktop study/final/18106594-001-r-rev0-1910 bank street-september 2018.docx

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IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practicing under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client, **RioCan Management Inc**. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder cannot be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

The information, recommendations and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without Golder's express written consent. If the report was prepared to be included for a specific permit application process, then the client may authorize the use of this report for such purpose by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process, provided this report is not noted to be a draft or preliminary report, and is specifically relevant to the project for which the application is being made. Any other use of this report by others is prohibited and is without responsibility to Golder. The report, all plans, data, drawings and other documents as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder, who authorizes only the Client and Approved Users to make copies of the report, but only in such quantities as are reasonably necessary for the use of the report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof to any other party without the express written permission of Golder. The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the Client cannot rely upon the electronic media versions of Golder's report or other work products.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by the Client, communications between Golder and the Client, and to any other reports prepared by Golder for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder cannot be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

IMPORTANT INFORMATION AND LIMITATIONS
OF THIS REPORT (cont'd)

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. **The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report.** The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

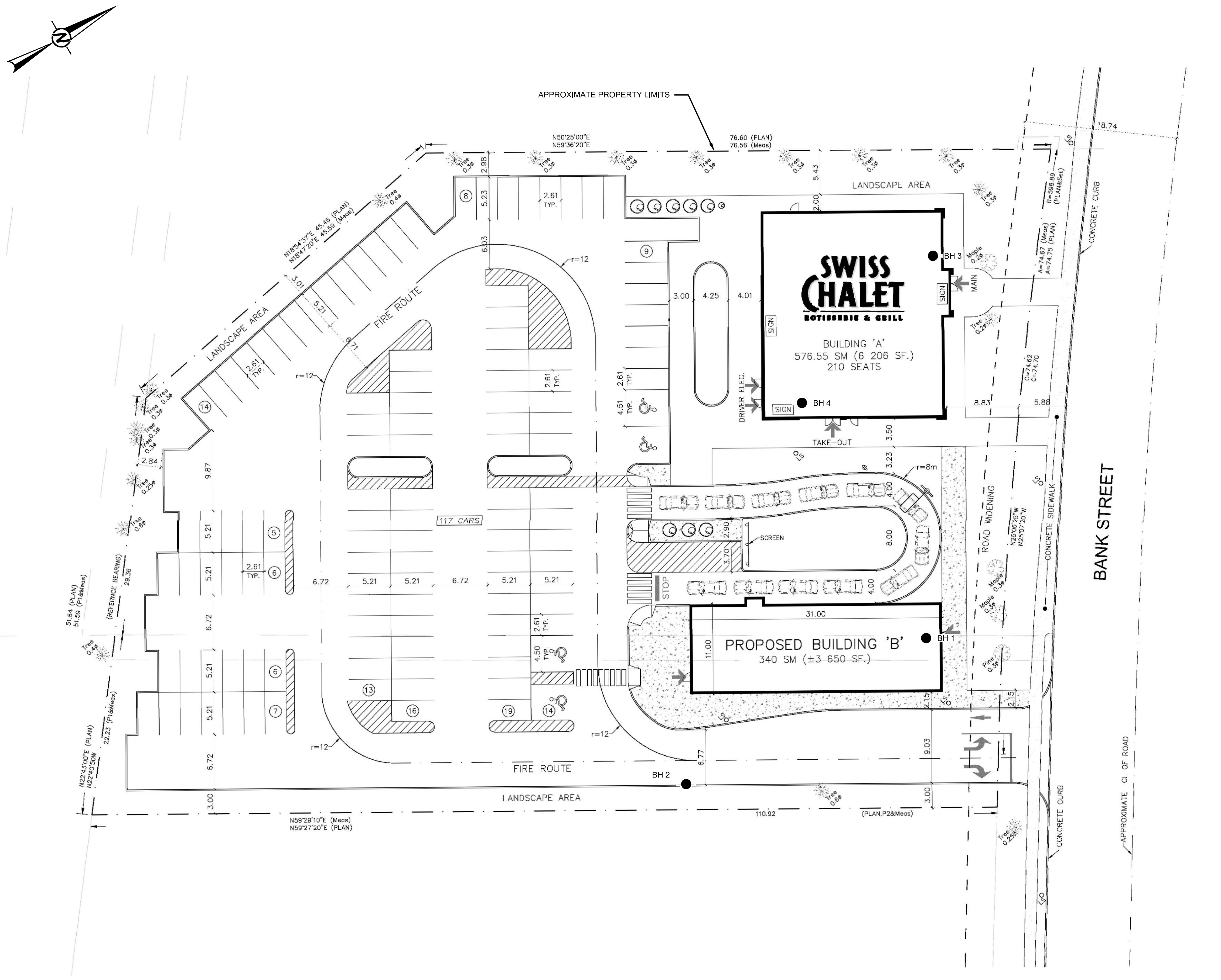
Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

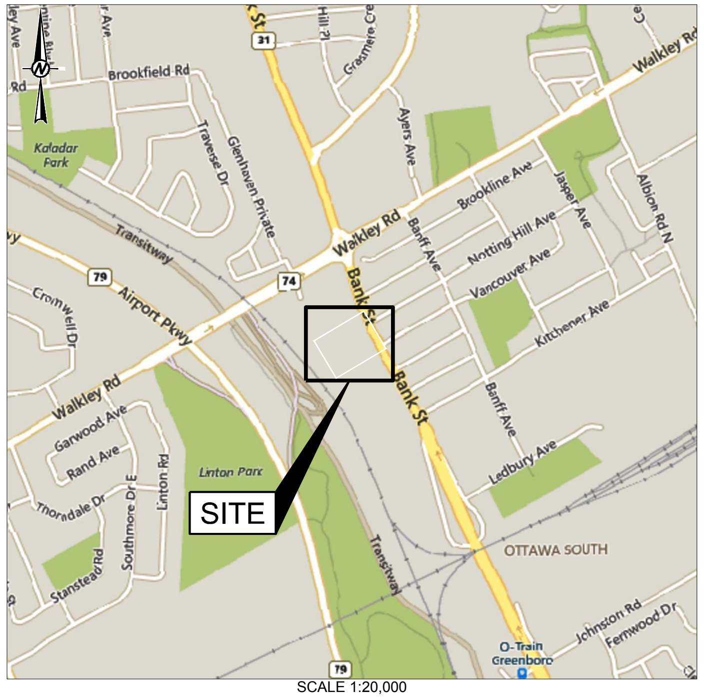
Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder's report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder's report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.




KEY MAP

SCALE 1:20,000

LEGEND

● APPROXIMATE BOREHOLE LOCATION, PREVIOUS INVESTIGATION BY GOLDER ASSOCIATES LTD., REPORT NO. 791-2167 (AUGUST 1979)

REFERENCE(S)

1. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: MTM ZONE 9, VERTICAL DATUM: CGVD28

0 10 20
1:500 METRES

CLIENT
RIOCAN MANAGEMENT INC.

PROJECT
GEOTECHNICAL DESKTOP STUDY
PROPOSED STARBUCKS BUILDING
1910 BANK STREET, OTTAWA, ONTARIO

TITLE
SITE PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2018-08-15
DESIGNED	----
PREPARED	JM
REVIEWED	SG
APPROVED	NRL

PROJECT NO.	CONTROL	REV.	FIGURE
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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25 mm
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APPENDIX A

Abbreviations and Symbols

Record of Boreholes from Previous Study (791-2167)

Relevant Laboratory Testing from Previous Study (791-2167)

LIST OF ABBREVIATIONS

The abbreviations commonly employed on each "Record of Borehole," on the figures and in the text of the report, are as follows:

I. SAMPLE TYPES

AS	auger sample
CS	chunk sample
DO	drive open
DS	Denison type sample
FS	foil sample
RC	rock core
ST	slotted tube
TO	thin-walled, open
TP	thin-walled, piston
WS	wash sample

II. PENETRATION RESISTANCES

Dynamic Penetration Resistance: The number of blows by a 140-pound hammer dropped 30 inches required to drive a 2-inch diameter, 60 degree cone one foot, where the cone is attached to 'A' size drill rods and casing is not used.

Standard Penetration Resistance, *N*: The number of blows by a 140-pound hammer dropped 30 inches required to drive a 2-inch drive open sampler one foot.

WH	sampler advanced by static weight—weight, hammer
PH	sampler advanced by pressure—pressure, hydraulic
PM	sampler advanced by pressure—pressure, manual

III. SOIL DESCRIPTION

(a) *Cohesionless Soils*

Relative Density	*N, blows/ft.*
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) *Cohesive Soils*

Consistency	c_u, *lb./sq. ft.*
Very soft	Less than 250
Soft	250 to 500
Firm	500 to 1,000
Stiff	1,000 to 2,000
Very stiff	2,000 to 4,000
Hard	over 4,000

IV. SOIL TESTS

C	consolidation test
H	hydrometer analysis
M	sieve analysis
MH	combined analysis, sieve and hydrometer[1]
Q	undrained triaxial[2]
R	consolidated undrained triaxial[2]
S	drained triaxial
U	unconfined compression
V	field vane test

NOTES:

[1] Combined analyses when 5 to 95 per cent of the material passes the No. 200 sieve.

[2] Undrained triaxial tests in which pore pressures are measured are shown as $\bar{Q}$ or $\bar{R}$.

LIST OF SYMBOLS

I. GENERAL

$\pi = 3.1416$

e = base of natural logarithms 2.7183

$\log_e a$ or $\ln a$, natural logarithm of a

$\log_{10} a$ or $\log a$, logarithm of a to base 10

t	time
g	acceleration due to gravity
V	volume
W	weight
M	moment
F	factor of safety

II. STRESS AND STRAIN

u	pore pressure
σ	normal stress
σ'	normal effective stress ($\bar{\sigma}$ is also used)
τ	shear stress
ϵ	linear strain
ϵ_{xy}	shear strain
ν	Poisson's ratio (μ is also used)
E	modulus of linear deformation (Young's modulus)
G	modulus of shear deformation
K	modulus of compressibility
η	coefficient of viscosity

III. SOIL PROPERTIES

(a) *Unit weight*

γ	unit weight of soil (bulk density)
γ_s	unit weight of solid particles
γ_w	unit weight of water
γ_d	unit dry weight of soil (dry density)
γ'	unit weight of submerged soil
G_s	specific gravity of solid particles $G_s = \gamma_s/\gamma_w$
e	void ratio
n	porosity
w	water content
S_r	degree of saturation

(b) *Consistency*

w_L	liquid limit
w_P	plastic limit
I_P	plasticity index
w_S	shrinkage limit
I_L	liquidity index $= (w - w_P)/I_P$
I_C	consistency index $= (w_L - w)/I_P$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
D_r	relative density $= (e_{max} - e)/(e_{max} - e_{min})$

(c) *Permeability*

h	hydraulic head or potential
q	rate of discharge
v	velocity of flow
i	hydraulic gradient
k	coefficient of permeability
j	seepage force per unit volume

(d) *Consolidation (one-dimensional)*

m_v	coefficient of volume change $= -\Delta e/(1+e)\Delta\sigma'$
C_c	compression index $= -\Delta e/\Delta \log_{10} \sigma'$
c_v	coefficient of consolidation
T_v	time factor $= c_v t/d^2$ (d, drainage path)
U	degree of consolidation

(e) *Shear strength*

τ_f	shear strength	
c'	effective cohesion intercept	in terms of effective stress $\tau_f = c' + \sigma' \tan \phi'$
ϕ'	effective angle of shearing resistance, or friction	
c_u	apparent cohesion*	in terms of total stress $\tau_f = c_u + \sigma \tan \phi_u$
ϕ_u	apparent angle of shearing resistance, or friction	
μ	coefficient of friction	
S_t	sensitivity	

*For the case of a saturated cohesive soil, $\phi_u = 0$ and the undrained shear strength $\tau_f = c_u$ is taken as half the undrained compressive strength.

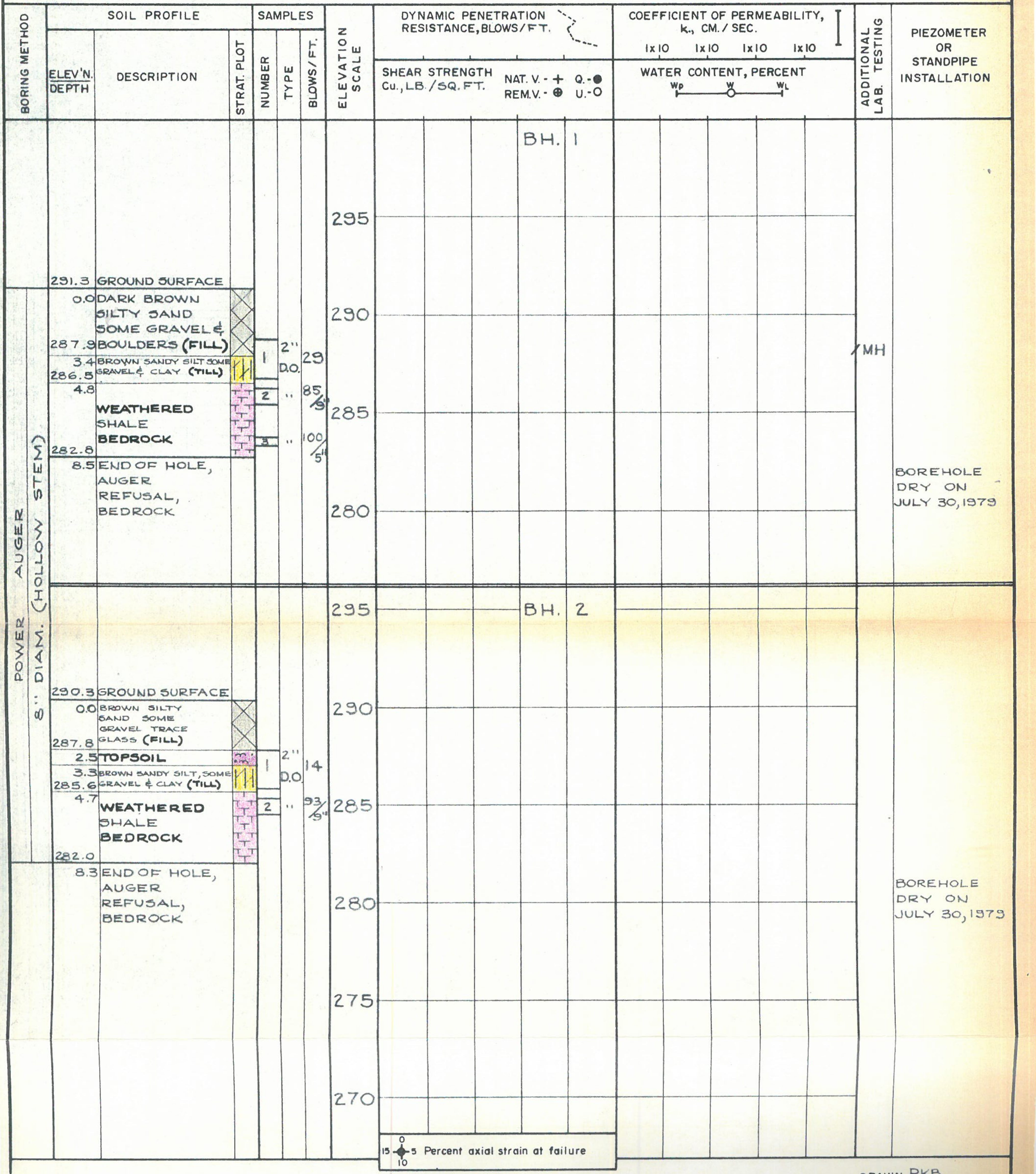
Form G.A.-D-I.

Project No. 791-2167

RECORD OF BOREHOLES 1 & 2

LOCATION See Figure 2
BORING DATE JULY 30, 1979
DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.
PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.



BORING METHOD: POWER AUGER 8" DIAM. (HOLLOW STEM)

BH. 1

ELEV'N. DEPTH	DESCRIPTION	SAMPLES NUMBER	TYPE	BLOWS / FT.	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
291.3	GROUND SURFACE					
0.0 287.9	DARK BROWN SILTY SAND SOME GRAVEL & BOULDERS (FILL)					
3.4 286.5	BROWN SANDY SILT SOME GRAVEL & CLAY (TILL)	1	2" D.O.	29	MH	
4.8 282.8	WEATHERED SHALE BEDROCK	2	"	85/5"		
		3	"	100/5"		
8.5	END OF HOLE, AUGER REFUSAL, BEDROCK					BOREHOLE DRY ON JULY 30, 1979

BH. 2

ELEV'N. DEPTH	DESCRIPTION	SAMPLES NUMBER	TYPE	BLOWS / FT.	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
290.3	GROUND SURFACE					
0.0 287.8	BROWN SILTY SAND SOME GRAVEL TRACE GLASS (FILL)					
2.5	TOPSOIL	1	2" D.O.	14		
3.3 285.6	BROWN SANDY SILT, SOME GRAVEL & CLAY (TILL)					
4.7 282.0	WEATHERED SHALE BEDROCK	2	"	93/9"		
8.3	END OF HOLE, AUGER REFUSAL, BEDROCK					BOREHOLE DRY ON JULY 30, 1979

VERTICAL SCALE
1 IN. TO 5 FT.

Golder Associates

DRAWN RKB
CHECKED BG

Form G.A.-D-1.

Project No. 791-2167

RECORD OF BOREHOLES 3 & 4

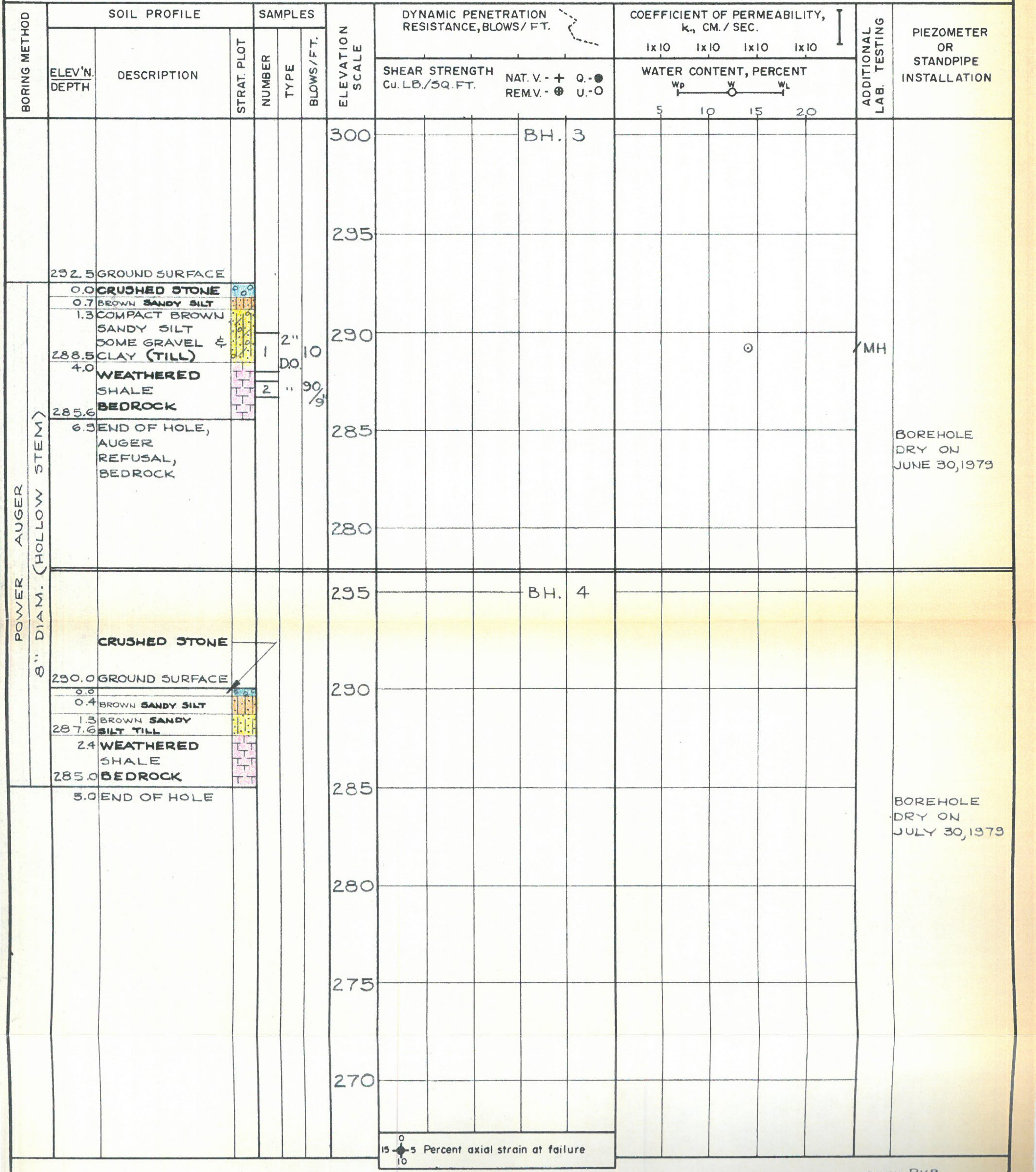
LOCATION See Figure 2

BORING DATE JULY 30,1979

DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.

PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.



BH. 3

ELEV'N. DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS/FT.	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
292.5	GROUND SURFACE					
0.0	**CRUSHED STONE**					
0.7	BROWN **SANDY SILT**					
1.3 288.5	COMPACT BROWN SANDY SILT SOME GRAVEL & CLAY **(TILL)**	1	2" D.O.	10	MH	
4.0 285.6	**WEATHERED** SHALE **BEDROCK**	2	"	90/9"		
6.9	END OF HOLE, AUGER REFUSAL, BEDROCK					BOREHOLE DRY ON JUNE 30,1979

BH. 4

ELEV'N. DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS/FT.	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
290.0	GROUND SURFACE					
0.0	**CRUSHED STONE**					
0.4	BROWN **SANDY SILT**					
1.3 287.6	BROWN **SANDY SILT TILL**					
2.4 285.0	**WEATHERED** SHALE **BEDROCK**					
5.0	END OF HOLE					BOREHOLE DRY ON JULY 30,1979

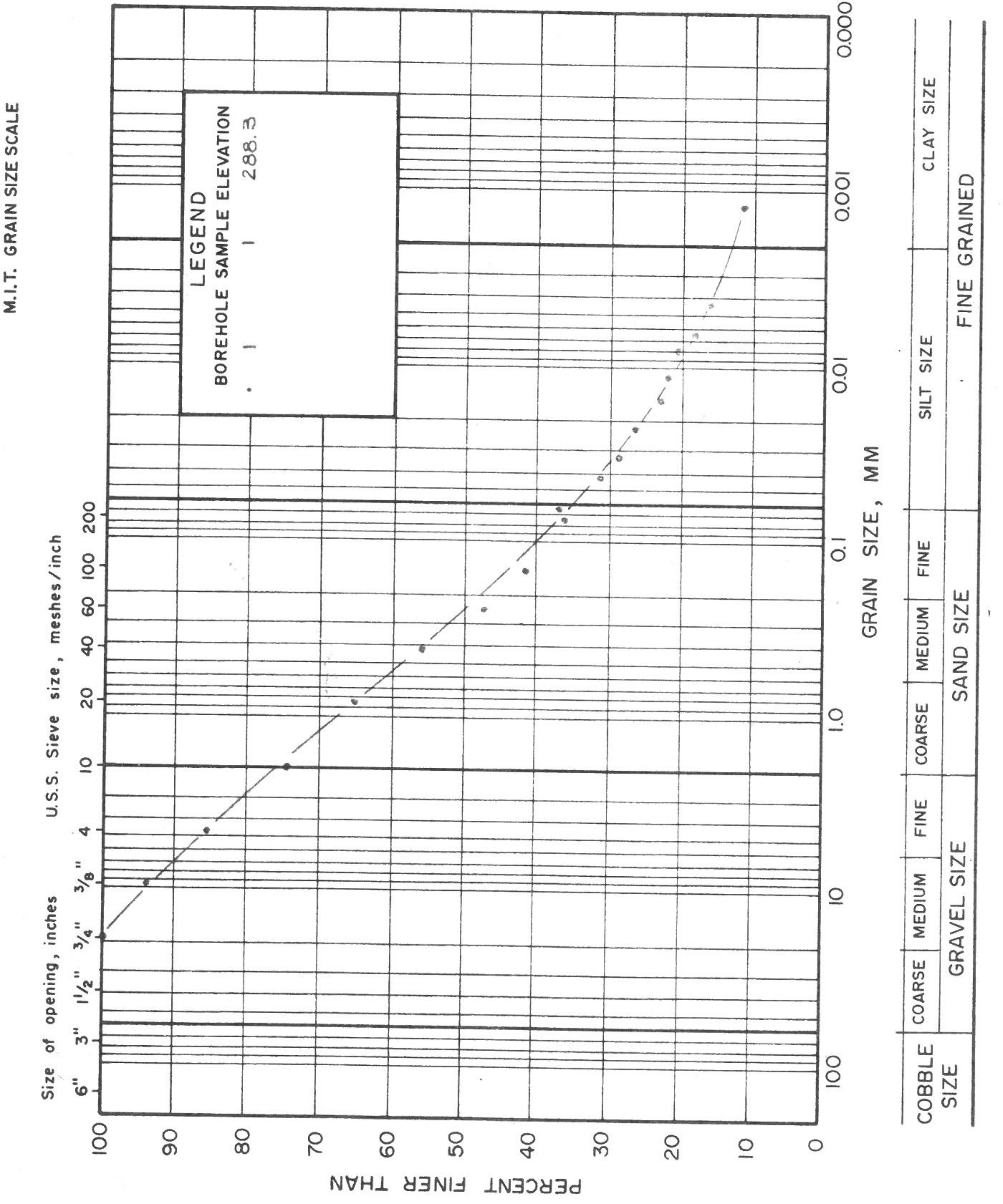
VERTICAL SCALE
1 IN. TO 5 FT.

Golder Associates

DRAWN RKB
CHECKED BG

GRAIN SIZE DISTRIBUTION
SILTY SAND FILL

FIGURE 3



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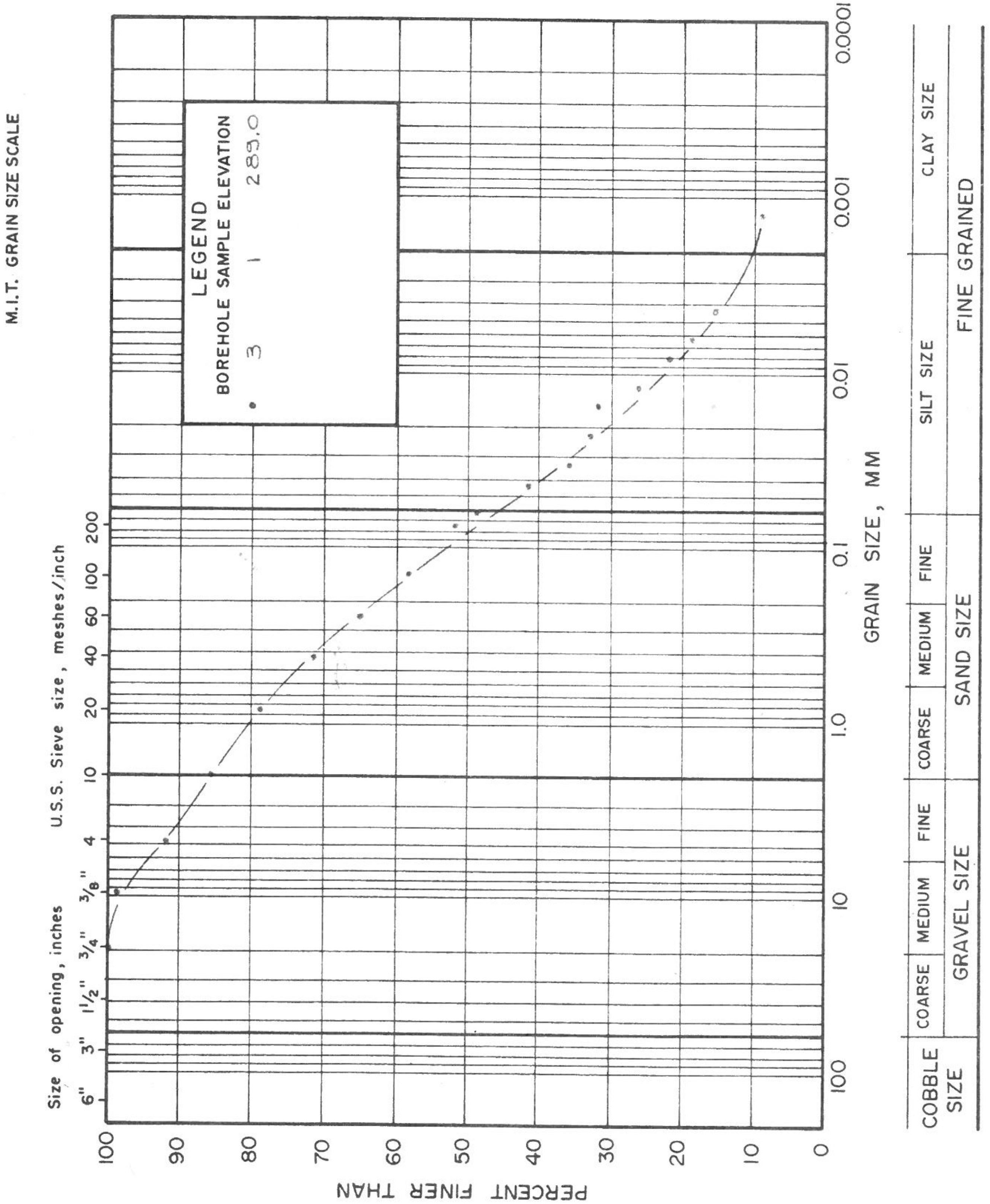
GRAIN SIZE DISTRIBUTION
SANDY SILT TILL

FIGURE 4



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